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# **Atmospheric and Spectroscopic Research in the Far Infrared**

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Final Report

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Submitted by

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## Summary of Research

The spectroscopic measurements of molecular parameters constitute one of the major areas of our research program. This part of our program has been conducted in close collaboration with Smithsonian Astrophysical Observatory (SAO) and National Institute of Standards and Technology (NIST). The references on HO<sub>2</sub>, OH, and O<sub>2</sub> that appear on the publication list are examples of this type of work completed during the grant period. These pressure-broadening studies have provided the kind of improvements needed in the database for retrieving atmospheric profiles from far infrared limb sensing data.

One example of this linkage between the pressure broadening studies and the improvements in data retrieval is described in the paper on HBr (paper #4, publication list). The retrieval of the concentration profile of this important species from the IBEX data was facilitated by a number of performance improvement factors, not the least of which was the database improvements. Following paragraph summarizes our laboratory spectroscopic studies conducted during the grant period.

We attempted to measure the pressure broadening coefficients of the O<sub>2</sub> lines in the 50 and 117 cm<sup>-1</sup> regions. An accurate characterization of these lines using the IBEX detector system was needed to analyze the flight data. These are difficult lines to measure because they arise from weak magnetic dipole transitions. We used a 4-meter absorption cell to obtain the pressure broadening coefficients for the 50 and 83 cm<sup>-1</sup> lines (paper #3). We also completed the pressure broadening studies including the temperature dependence of two lines of OH at 83 and 118 cm<sup>-1</sup>. These two lines are important not only for the balloon data retrieval work but also for the future project proposals. The 118 line in particular was measured by us years ago, and it had a suspicious temperature dependence. We pursued this problem over the last two years, and we have now resolved the discrepancies. The results of this study have been submitted for publication. We also completed the pressure broadening studies of HF. The analysis is completed, and a manuscript is in preparation. Pressure broadening coefficients for H<sub>2</sub>O at 88 cm<sup>-1</sup> and for O<sub>3</sub> at 114 cm<sup>-1</sup> have been measured and results published (paper #8).

Another area of focus in our program is the far infrared detector research. Our collaboration with Professor Peter Ade's group at the Queen Mary & Westfield College has been extremely productive. During the grant period, the performance of the flight detector system was improved dramatically. Our goal is to adapt the new sensor technology to the laboratory detector at NIST TuFIR spectrometer, including a cold grating filter system. Preliminary design study leads us to believe that the laboratory detector performance could be improved by an order of magnitude.

The third area of focus deals with data distribution and dissemination. The massive amount of balloon data are being analyzed and readied for distribution. During the grant period, we received a grant from the Research Corporation for science outreach called "Partners in Science."

We used the resources from that grant to compile the data atlas for the IBEX'94 dataset. This two-volume set contained 720 sets of interferograms and spectra and an index listing.

## Publication List

1. K.V. Chance, K. Park, K.M. Evenson, L.R. Zink, and F. Stroh, "The Far Infrared Spectrum of HO<sub>2</sub>," *J. Molec. Spectrosc.* **172**, 407, 1995
2. K. Park, L.R. Zink, K.M. Evenson, K.V. Chance, and I.G. Nolt, "Pressure Broadening of the 83.869 cm<sup>-1</sup> Rotational Lines of OH by N<sub>2</sub>, O<sub>2</sub>, H<sub>2</sub>, and He," *J. Quant. Spectrosc. & Rad. Transfer* **55**, 285, 1996
3. K. Park, I.G. Nolt, T.C. Steele, L.R. Zink, K.M. Evenson, and K.V. Chance, "Pressure Broadening of the 50.873 cm<sup>-1</sup> and the 83.469 cm<sup>-1</sup> Molecular Oxygen Lines," *J. Quant. Spectrosc. & Rad. Transfer* **56**, 315, 1996
4. I.G. Nolt, P.A.R. Ade, F. Albioni, B. Carli, M. Carlotti, U. Cortesi, M. Epifani, M.J. Griffin, P.A. Hamilton, C. Lee, G. Lepri, F. Mencaraglia, A.G. Murray, J.H. Park, K. Park, P. Raspollini, M. Ridolfi and M.D. Vanek, "Stratospheric HBr Concentration Profile Obtained from Far-infrared Emission Spectroscopy," *Geophysical Research Letters* **24**, 281, 1997
5. K. Park, *IBEX'94 DATA ATLAS*, (A compilation of 1994 balloon data in two volumes, 720 pages plus index), March, 1997
6. I.G. Nolt, P. A. R. Ade, B. Carli, F. Evans, B. T. Marshall, M. G. Mlynchzak, K. Park, J. M. Russell III, "Far Infrared Remote Sensing of Cirrus Cloud Parameters," *Proc. European Symp. On Aerospace Remote Sensing*, London, 22-26 September 1997
7. K.V. Chance, K. Park, K.M. Evenson, L.R. Zink, F. Stroh, E. Fink and D.A. Ramsay, "Molecular Constants for the Ground State of HO<sub>2</sub>," *J. Molec. Spectrosc* **183**, 418, 1997
8. K.V. Chance, K. Park, and K.M. Evenson, "Pressure Broadening of Far Infrared Rotational Transitions: 88.65 cm<sup>-1</sup> H<sub>2</sub>O and 114.47 cm<sup>-1</sup> O<sub>3</sub>," *J. Quant. Spectrosc. & Rad. Transfer* **59**, 687, 1998